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MIGRATION OF FUSED FALLOUT SIMULANT INTO SOILS

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MIGRATION OF FUSED FALLOUT SIMULANT INTO SOILS

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by

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ABSTRACT

The U. S. Naval Civil Engineering Laboratory conducted a study of the migration of fused fallout simulant into alternately frozen and thawed soils. Four different soils or soil mixtures were used; Monterey sand treated with Barium-140 and sodium silicate was the fallout simulant. Radiation levels were measured after each of twelve thaw-freeze cycles. It was concluded that the fused fallout simulant did not migrate into the soils. Further work is recommended using actual fallout debris.

INTRODUCTION

The Naval Civil Engineering Laboratory has been conducting studies on radiological decontamination methods for cold weather areas. It was deemed that a study of the migration of fallout in alternately frozen and thawed soils was in order since no previous work of such nature has been reported.

BACKGROUND

In defining a problem, certain conditions must be established. In this study it is assumed that a radioactive fallout-producing incident has occurred during the winter months. While residents of an area are in shelters, the fallout settles on various land surfaces. The ambient temperature varies and produces alternate thawing and refreezing of the soil surfaces. This alternation includes the fallout in the uppermost layer, at least by freezing it to the surface through contact with existing moisture. The questions that arise are: will the fallout migrate vertically down into the soil under this alternate thawing and freezing? and if so, how far will it migrate? This study was undertaken in an attempt to answer these questions.

TEST FACILITY

This experiment was conducted in the NCEL Cold Chamber. Four sheet metal trays (Figure 1) each containing four different types of moist soils, were arranged in a rectangular pattern (Figure 2) and were separated by a block wall (Figure 3). A heating unit (Figure 4) provided thermal radiation necessary for thawing the frozen soils, and a stepwise scanning spectrometer (Figure 5) measured gamma radiation emitted during the test. Graded (150 - 300 microns) Monterey sand treated with Barium-140 and then covered with a fused layer of sodium silicate was the fallout simulant. Plastic sheeting was placed under the trays to decrease the probability of contaminating the chamber through accidental spillage of the radioactive simulant.

Trays:

The metal trays were made of 1/16-inch thick mild steel sheet, and were four feet square by six inches deep. A four-inch wide lip was formed around the top and bent outward at a 45° angle.

Soils:

Four different soils were used to represent types that might be common in areas affected by cold weather. Those used were: beach sand, loam, loam mixed with small gravel, and crushed sandstone mixed with small gravel. All were obtained locally. The mixtures were prepared on a 50-50 volume basis in a conventional half-yard capacity concrete mixer.

Walls:

Hollow concrete blocks (16 inches by 8 inches by 8 inches) were used to form the separating walls. The walls were in the form of a cross, with each equal-length arm consisting of two thicknesses of blocks. By using half- and quarter-sized blocks it was possible to build the wall so that radiation from one tray could not travel in a straight line and affect radiation readings over any of the other trays. The voids in the blocks were filled with moist sand to further minimize side-radiation effects.

Heating unit:

A radiant heating unit (Figure 6) was constructed from ten 5-foot long heating elements, aluminum sheet, and fiberglass insulation. The heating elements were wired alternately in separate groups of five each and were insulated from the metallic cover by pieces of asbestos board. A sheet of polished aluminum was placed behind the heating elements to reflect heat downward onto the soils. Power was supplied to the heating unit through controls outside the chamber; the controls were always turned off when personnel were working inside the chamber. Control sections consisted of a safety switch, a rheostat, a voltmeter, and an ammeter, with a separate section wired to each group of heating elements.

Spectrometer:

A description of the spectrometer is given in Appendix A.

PROCEDURES

The radiological safety procedures followed in this experiment are given in Appendix B.

As soon as the test facility was assembled, the chamber temperature was lowered to 25 F. When probing the soils indicated that they were frozen, the heating unit was placed on one tray and the power turned on. After a predetermined period the power was turned off, the heating unit was removed from the tray, and the depth of thaw in the soil was measured. The heating unit was replaced, and thawing continued until approximately two inches of soil was thawed. Since this took slightly more than an hour for the first soil, one hour was set as the time that the several soils would be thawed. The heating unit was moved to each of the trays, turned on for an hour, turned off, and removed. The depth of thaw was checked, and in each case it was found to be approximately two inches. The soils were allowed to refreeze, which took about two hours.

When the soils were refrozen, quantities of Monterey sand treated with a total of 1.0 millicurie of Ba-140 were spread over the surface of the frozen soils. The counting procedure was established, as given in Appendix A, after which the initial radiation level was measured over each tray. Each soil was thawed and allowed to refreeze; after each thaw-freeze cycle the radiation level was again measured. After eleven cycles the trays of soils were vacuumed. The radiation level over each tray was measured immediately before and immediately after the tray was vacuumed.

All soils were placed in covered galvanized iron cans, along with contaminated equipment that was not wanted. The cans were turned over to a firm licensed to dispose of radioactive wastes.

RESULTS

Table I shows the results obtained by vacuuming the several soils.

Table I. Effect of Vacuuming on Radiation Level

Tray Number	First Vacuuming Counts Before	First Vacuuming Counts After	First Vacuuming Percent Removed	Second Vacuuming Counts Before	Second Vacuuming Counts After	Second Vacuuming Percent Removed	Total Decrease
1	37,211	2002	94.6	3109	2157	30.6	96.3
2	29,884	3103	89.6	3110	970	68.8	96.8
3	34,994	3951	88.7	3814	1041	72.7	96.9
4	34,259	3050	91.1	2862	1292	54.9	96.0

A single vacuuming removed a minimum of 88 percent of the detectable activity, along with up to 1/16 of an inch of soil. A second vacuuming increased the percent activity removed to 96 percent, and also removed another thin layer of soil.

Figure 7 shows the radiation levels after successive freeze-thaw cycles; the actual measurements were multiplied by decay factors to indicate the original activities required to yield the measurements. A horizontal dashed line is used with each curve to show what the radiation level would be if neither migration nor decay had taken place. The line is based on the initial radiation level as measured before beginning the freeze-thaw

cycles. The curves show an increase in radioactivity, rather than the uniform intensity that would be expected.

DISCUSSION

When a single vacuuming of the soils removed at least 88 percent of the activity along with about a 1/16 inch deep layer from the soil surfaces, it was assumed that essentially no vertical migration of the fused fallout simulant had taken place. It cannot be assumed that the same would be true if natural fallout had been used, since natural fallout is at least partly leachable. Thus, the radioactive materials could be dissolved and then infiltrate beyond the surface of the soil on which it falls.

It is not possible to determine the cause of the apparent increase in radioactivity. Variations in the power supply or the performance of internal components of the counting equipment may account for the increase.

CONCLUSIONS

1. Migration of the fused fallout simulant particles was insignificant in this case.

2. The tests should be repeated using additional types of radioactive fallout and other counting techniques.

FUTURE PLANS

These tests will be repeated during Fiscal Year 64, with certain changes. The work will be done in an environmental chamber at Point Mugu, as NCEL no longer has a chamber available for this work. Both fused and leachable simulant will be used, as will true fallout material if it is available. The number of thaw-freeze cycles will be increased to improve the opportunity for migration to occur. The size of the trays will be reduced to minimize the waste disposal problem.

Appendix A

OPERATION OF SPECTROMETER AND COUNTING PROCEDURE

The stepwise scanning spectrometer consists of a shielded scintillation probe (Figure 1), a spectrometer section, a scaler section, and a printing section (Figure 5). The probe includes a thallium-activated sodium idodide crystal and a photomultiplier tube. Radiations from a given source are registered on the crystal as light flashes. Each flash is proportional in intensity to the energy deposited in the crystal by a particular gamma ray. The flash is detected by the photomultiplier tube which converts the energy to an amplified voltage impulse, and transmits the impulse to the spectrometer section. The impulse is again amplified and its magnitude compared to upper and lower limits which are determined by the channel being counted. If the impulse is between two limits, a signal is sent to the scaler which registers the signal as a single count.

After a pre-set time the scaler quits accepting signals or impulses from the spectrometer. The scaler then tells the printing section to record the channel which was counted, the total counts, and the time of counting. The printer does this and, if the assembly is set for automatic operation, switches the spectrometer to the next channel. At the same time the printer tells the scaler to accept signals from the spectrometer again, and the counting process begins for another channel.

When the several soils had been frozen and covered with the fused radioactive fallout simulant, the scintillation probe was positioned over the center of one of the trays and a spectrum obtained (Figure 8a). The peaks corresponding to 0.815 Mev and 1.6 Mev are quite prominent, so they were monitored during the experiment. The gain shown in Figure 8a was doubled for the 1.6-Mev peak and quadrupled for the 0.815-Mev peak so that either peak could be measured around channel 40 of the spectrometer. A seven-channel spread was used for finding the total number of counts in each peak. The spread is indicated in Figure 8b for the 0.815-Mev peak. The difference in peak height between Figures 8a and 8b is attributable to the change in gain. Corrections for minor changes in gain were made by moving the seven-channel spread a short distance along the spectrum until the maximum count rate was found.

Appendix B

RADIOLOGICAL SAFETY PROCEDURES FOR USE OF RADIOACTIVE SIMULANT (Ba 140-La 140) IN USNCEL COLD CHAMBER EXPERIMENTS

1. Rules and regulations set forth in Title 10, Code of Federal Regulations, Chapter 1, Part 20 and 30, will be complied with. Also the licensee will adhere to USNCEL Instruction 5100.10A of 4 August 1961 and letter of 29 March 1961 signed by D. G. Iselin, Acting Commanding Officer.

2. The total amount of activity to be used will not exceed 1 millicurie of Barium 140-Lanthanum 140. This will give a dose of about 1.72 milliroentgens/hr at one yard. Since this is to be divided into 4 equal parts, the dose rate from any of the trays used will not exceed approximately 15 mr/hr at 6" from the surface of the tray. At the working distance of 2' for the scintillation counter the dose rate should not be over 1 mr/hr.

3. In addition, the following procedures and safety regulations are to be followed:

a. The material as received from USNRDL, San Francisco, California, should be shipped in a container which complies with the AEC and U.S. Department of Commerce shipping regulations.

b. The loading of sand into the trays can be done in the cold chamber. A 10-mil plastic sheet can be spread under each tray extending 3 feet beyond the edge of the tray to collect any sand which may spill when the fallout simulant is being spread over the trays. Protective clothing, masks, and gloves should be used during the spreading operation. People engaged in this operation will carry pocket ionization chambers as well as self-reading electroscopes (0-200 mr) and film badges. The operation will be monitored with a Cutie Pie Radiation Detector. A Colman 20 Liters/min air sampler will be used to detect any air borne radioactivity.

c. At least one licensed user will be present at all times that any work is being done in the cold chamber.

d. The cold chamber will be locked at all times except when a licensed user is present, and the keys will be retained only by licensed users.

e. Records of all readings will be kept in a log book.

f. During the entire period of the experiment in the cold chamber, all personnel entering the cold chamber (whether for experimental work or for maintenance) will have the radiation detecting devices mentioned above. While decontamination procedures are being tested, all personnel will wear the protective clothing mentioned in paragraph 3b, and the air sampler will be used.

4. Any radioactive waste material will be stored in an appropriately marked can with a lid. After a thorough vacuum cleaning of the cold chamber to remove all loose contamination, all material removed in final decontamination procedures will be stored in this waste can.

5. Upon completion of the experiment, all the sand from the trays and other contaminated material (determined by survey with a thin window Geiger tube survey instrument) will be placed in suitable containers for disposal.

6. A final survey of the chamber and trays and all equipment used in this operation will be made with a thin window Geiger tube survey instrument.

7. All contaminated material in cans will be picked up and disposed of by a commercial disposal company.

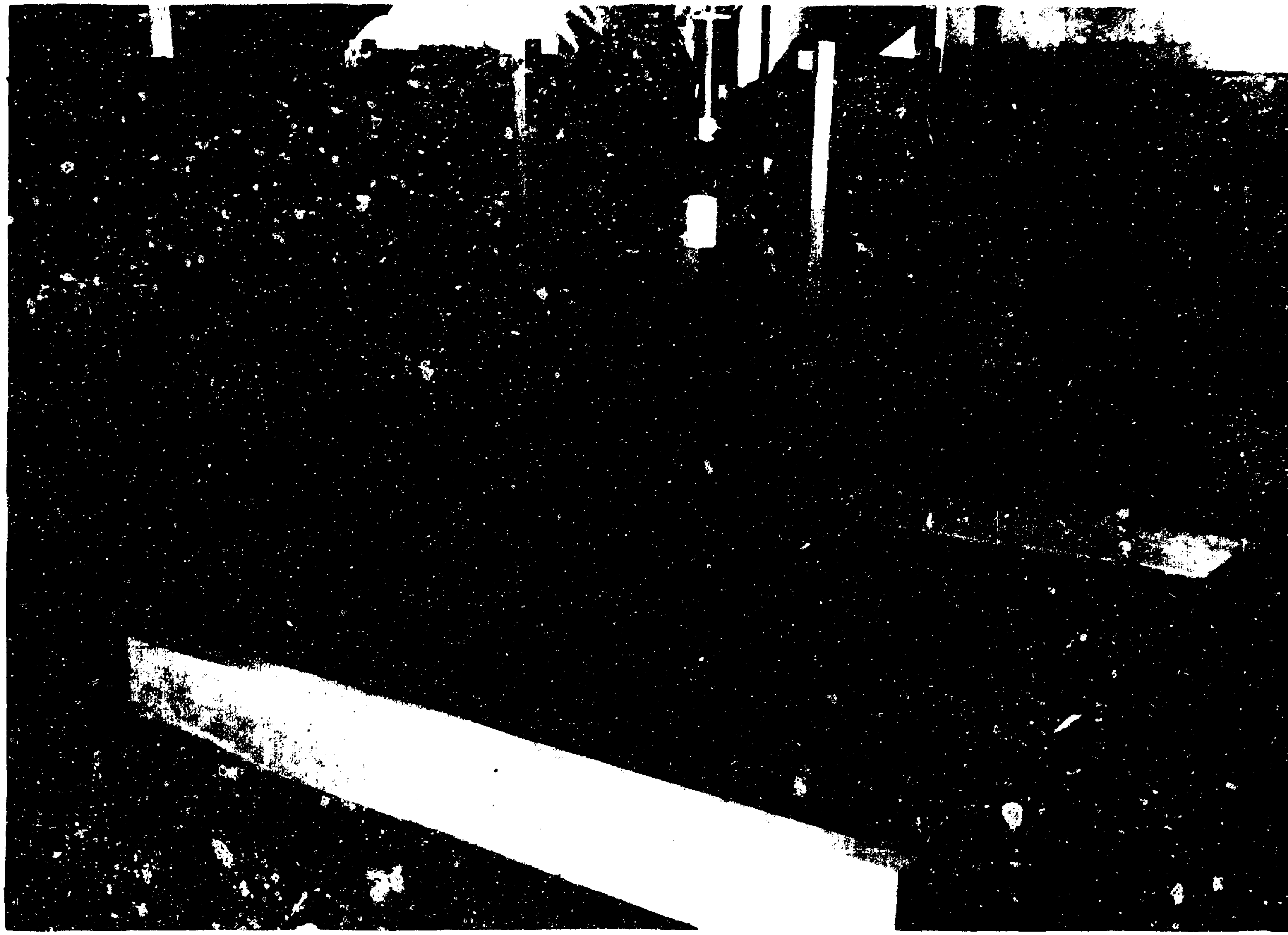


Figure 1. Sheet metal tray and shielded scintillation probe

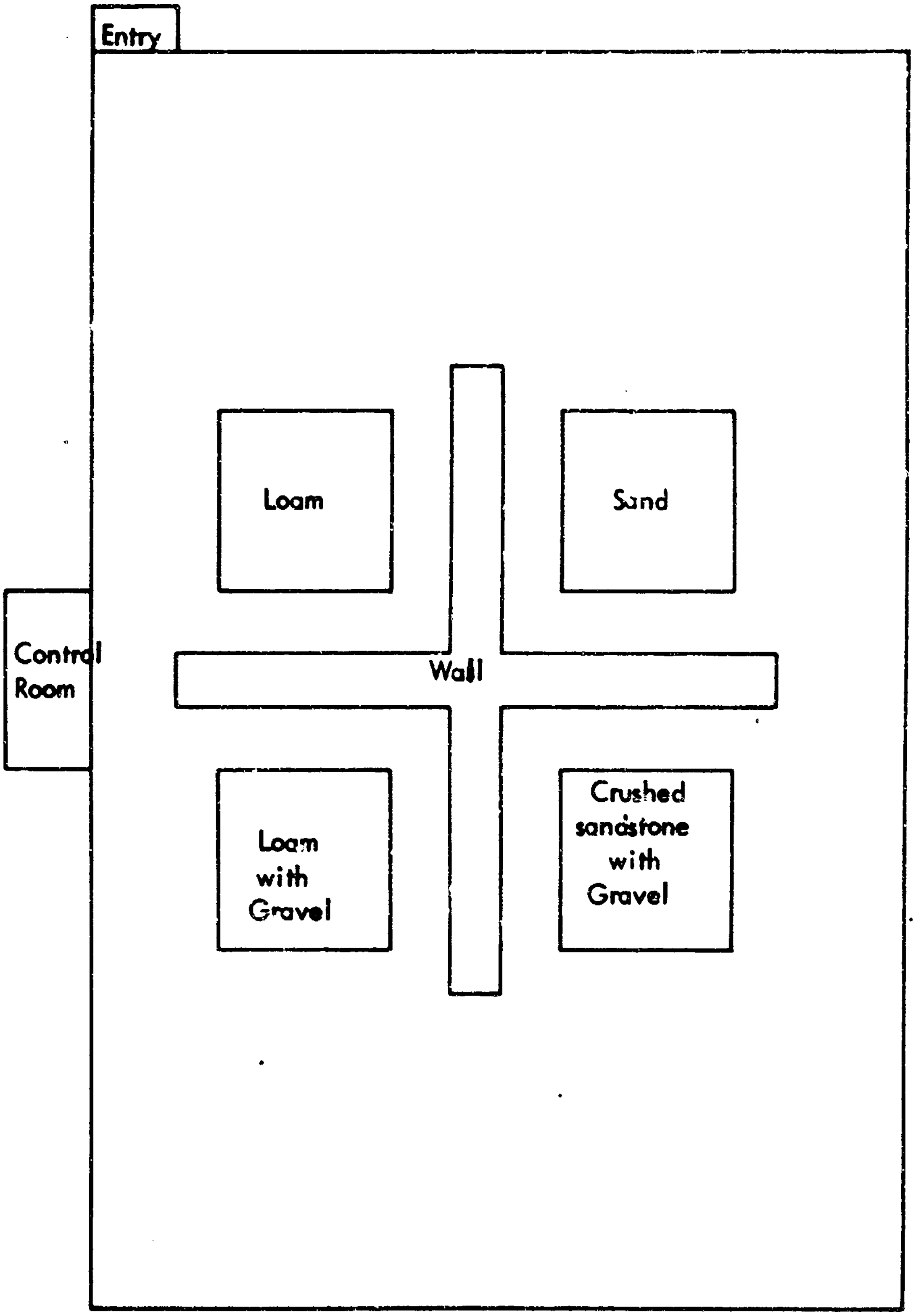


Figure 2. Cold Chamber arrangement.

Figure 3. Block wall, trays, heating unit, and detector

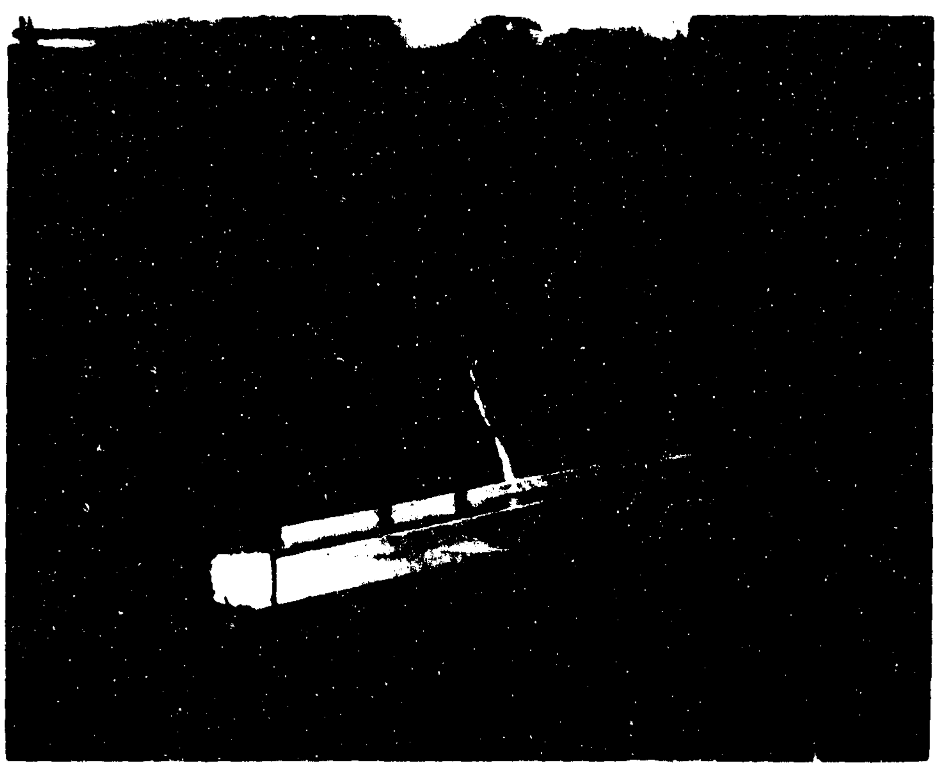


Figure 4. Heating unit in place

Figure 5. Spectrometer

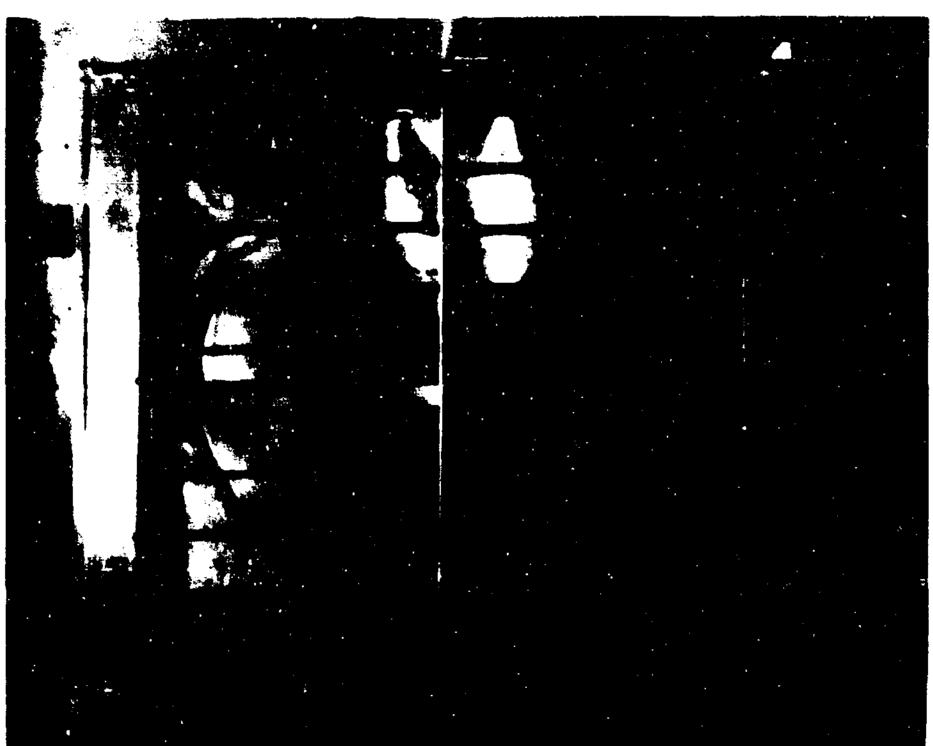


Figure 6. Heating unit, showing heating elements and polished aluminum sheet

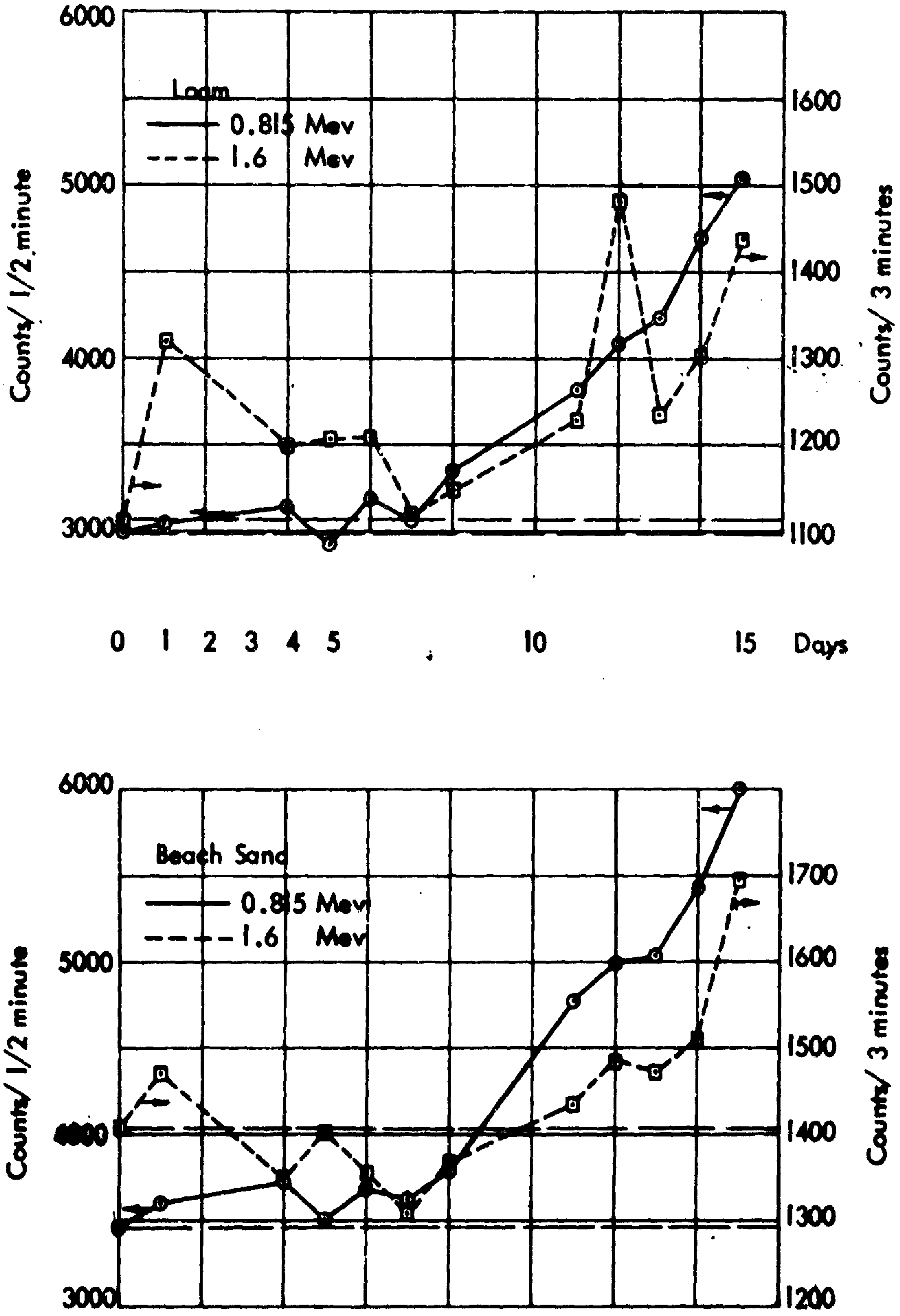
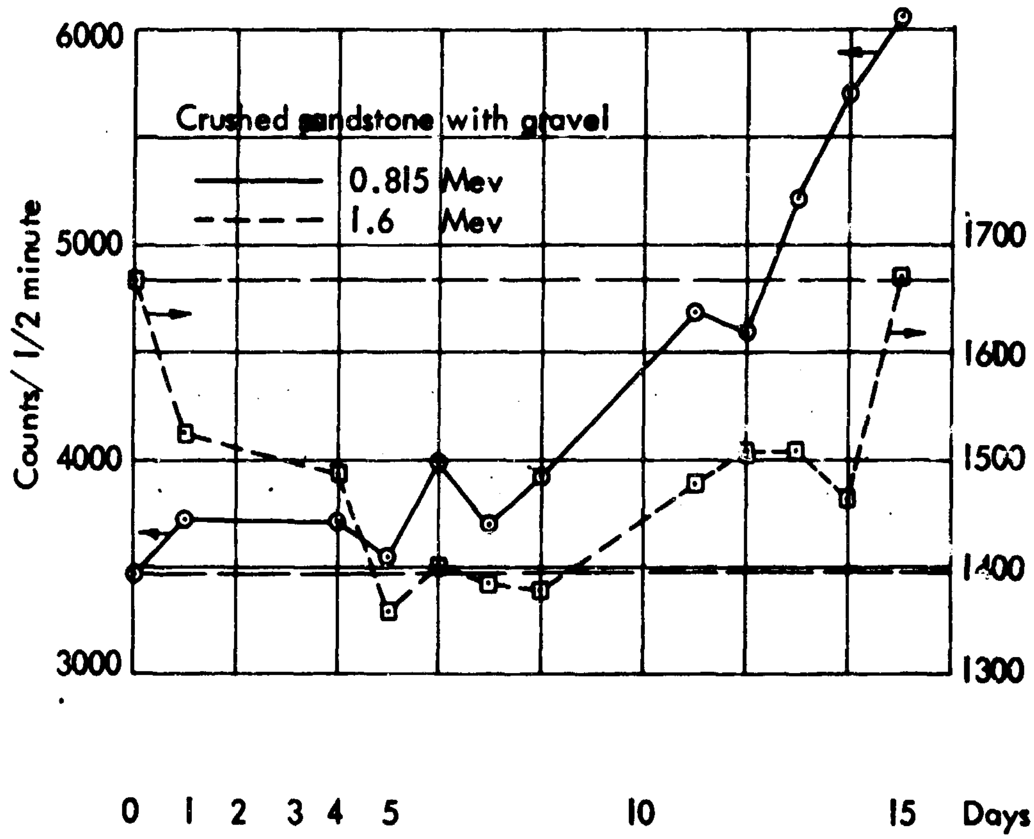


Figure 7. Radiation levels after successive thaw-freeze cycles



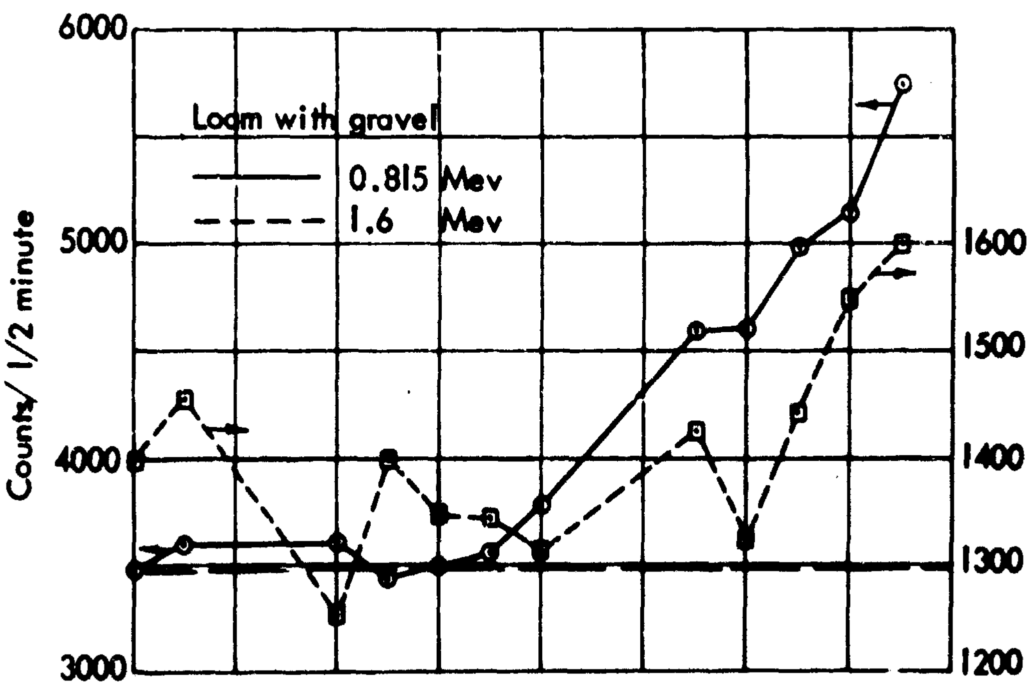


Figure 7 (contd.). Radiation levels after successive thaw-freeze cycles

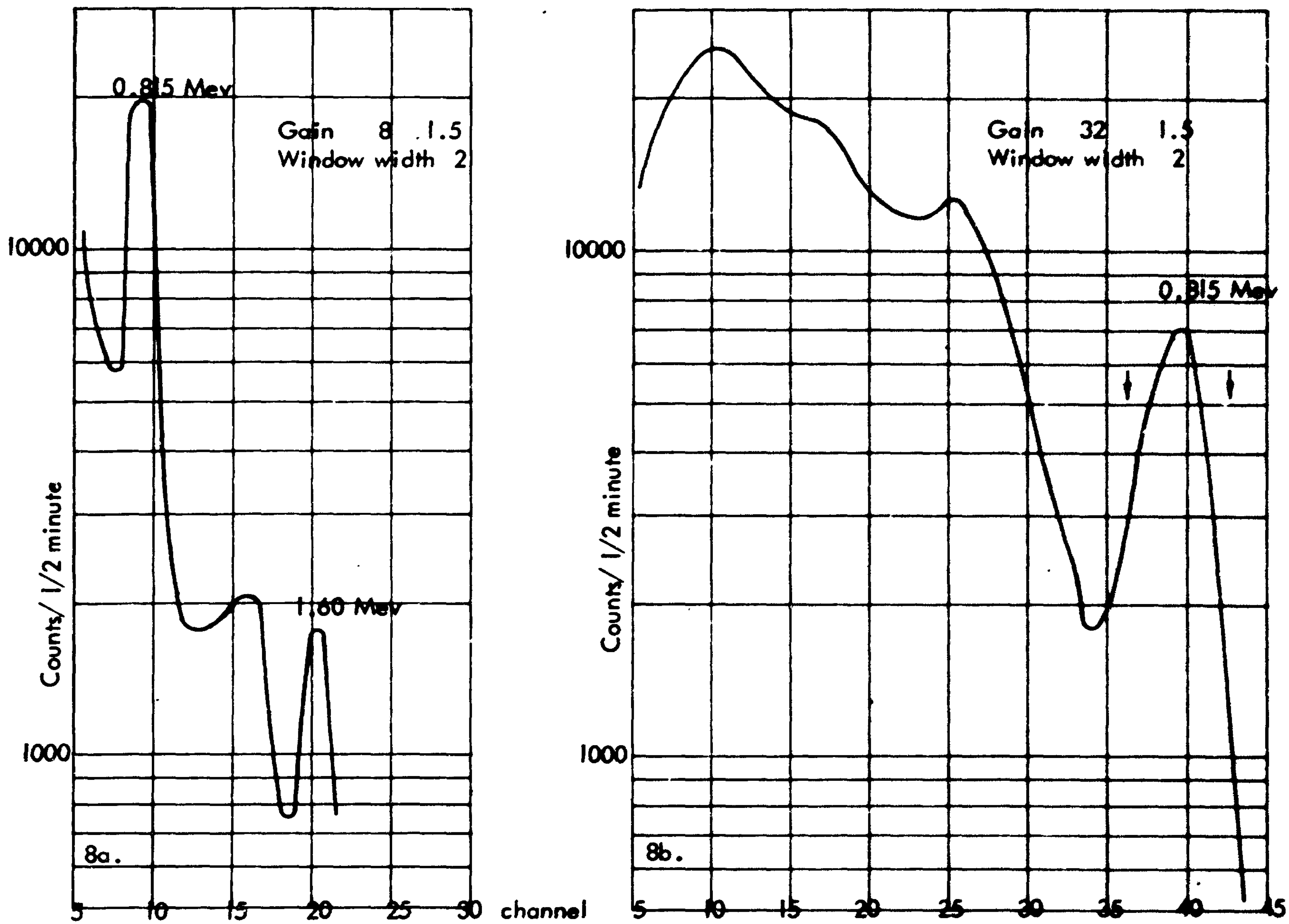


Figure 8. Barium 140 - Lanthanum 140 Spectra